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# MISCELLANEOUS PAPERS.

The Economics of Crop Disposal . . . . . C. S. SCOFIELD

The Abortion of Fruiting Branches in Cotton . . . . . O. F. COOK

Fruit Growing on the Truckee-Carson Project . . . . . F. B. HEADLEY and VINCENT FULKERSON

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Geo. E. Coublier.

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## BUREAU OF PLANT INDUSTRY.

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*Editor,* J. E. ROCKWELL.
*Chief Clerk,* JAMES E. JONES.

# THE ECONOMICS OF CROP DISPOSAL.[1]

By CARL S. SCOFIELD, *Agriculturist in Charge of Western Irrigation Agriculture.*

## INTRODUCTION.

It is now more than 20 years since the beginning of the investigations which were finally consolidated in the organization of the Bureau of Plant Industry 12 years ago. These investigations have been devoted primarily to the problems of crop production. Studies of our native plants, the introduction of new plants, plant breeding, the control of plant diseases, and investigations of plant nutrition have been among the more important features of this work. We have devoted but little attention to those problems which confront the farmer in the disposal of his crop. In other words, the chief aim of our investigations and of our educational work as well has been to stimulate the growth of those "two blades of grass."

In this work we have been measurably successful. Nevertheless, the cost of living has continued to increase, and this is a matter with which we are professionally concerned, since probably more than any other single body of men we have to do with the fundamental factors of that complex problem. It seems to me obvious that if we are to attack that problem effectively we must look into the methods of crop disposal as well as into those of crop production. Such an inquiry, if undertaken seriously, may be expected to yield results as striking, as far-reaching, and as beneficial as any that we have already achieved.

If it is a proper function of the Bureau of Plant Industry to work out the problems of our agricultural industries, there can be no doubt as to the need or the propriety of investigating the problem of the disposal or utilization of crops. The advantageous disposal of a crop is quite as important as its successful production. The producer is continually harassed with doubt as to what crop or crops to plant or where or how best to market those which he has already grown.

The stabilization of food supplies has been one of the fundamental factors in the development of our civilization. From the time of

[1] Issued Mar. 22, 1913.
This paper was presented Feb. 4, 1913, as one of a series of lectures given before the scientific staff of the Bureau of Plant Industry.

our cave-dwelling ancestors there has been continuous progress in this direction. Yet we are not really many generations from the times of alternating feasts and famines, and there are to-day large sections, particularly in the Old World, where famines recur with cruel frequency.

## NEED OF UNIFORM DISTRIBUTION.

With very few exceptions, food scarcities are due rather to inadequate facilities for distribution than to actual lack of supply. In a majority of cases there is plenty of food in one country when there is a shortage in another. In a country as large as ours this is often true of its different parts. Something of the same sort applies with reference to the distribution of supplies throughout the year.

So much for the demand. Those who make it their business to produce supplies of food and clothing have the same desire for a uniform demand that the consumer has for a uniform supply. The greatest risks of agricultural production are the market risks. A uniform demand for any agricultural product at a price that in the average of seasons gives reasonable profits for production would relieve the farmer of one of his most perplexing problems.

The sugar-beet industry is a case in point. The price of this crop fluctuates but little from year to year, and the demand is never satisfied. A farmer may feel certain of a ready market and he knows about how much he will receive per ton, regardless of whether the country's acreage is large or small. Were it not for this one fact, the area devoted to sugar beets in this country would doubtless be much smaller than it is, for even under the most favorable conditions the profits from the production of sugar beets are not large.

In the Irish-potato industry a very different condition obtains. In this case the price fluctuates between wide limits. Every two or three years the crop is larger than the market can absorb and prices go so low that there is little or no profit to the producer. Thereupon the acreage is reduced, the supply runs short, and prices advance to a point at which the consumer comes to regard the potato as a luxury and stops buying it for daily use. And what is true of potatoes is true in a large measure of many other perishable crops.

The net result of this condition is a great economic waste. In times of plenty we are compelled to throw away great quantities of foodstuffs that at other times we would be glad to have. A glut in the market is of but temporary advantage to the consumer and a scarcity is of small advantage to the producer. It is true that wide price fluctuations may yield small profits one way or another to a few individuals, but in the long run such fluctuations result in large aggregate losses.

The first suggestion usually offered when this matter of crop disposal is discussed is the elimination of the middleman. In a more primitive industrial development or with a smaller population we might work out more readily a practicable way to provide direct communication between the producer and the consumer. Probably there is room for much improvement in lessening the cost of living through more extensive cooperative associations of buyers and of sellers. There is also much to be done in the way of preserving perishable products by evaporation, sterilization, and refrigeration. Anything that can be learned in this direction in the way of lessening the cost or extending the use of these methods will react directly in steadying the market in connection with perishable food supplies, and steadying the market is equivalent to increasing the profits of production and at the same time lessening the cost to the consumer.

With respect to the cold-storage business, probably the greatest present need is publicity. There is a profound suspicion that cold-storage houses are used more for maintaining high prices on certain commodities than for keeping them cheaply until times of scarcity. In times of plenty and of low prices it is possible under present conditions for the farsighted and forehanded to fill the storage houses with supplies to be unloaded judiciously and circumspectly on a high market. The requirement of adequate publicity as to the character and quantity of supplies in storage would constitute a long step toward securing economy in our national housekeeping. It seems to me that this is one of the very few ways in which legislation may be used to reduce the high cost of living.

## BETTER MEANS OF DISTRIBUTION.

The next point I wish to make may be illustrated by reference to such ordinary fruits as the apple, the orange, and the banana. Of these three the apple lends itself best to storage and to shipment and is probably the most extensively used and generally esteemed. Yet with all these advantages it is the crop which is subject to the widest price fluctuations and for the future development of which we have the greatest anxiety, speaking industrially; that is, we have the greatest fear of overproduction in the near future, with consequent losses to all producers. The reason for this apprehension lies in the fact that we do not have behind the apple crop such efficient agencies for distribution as exist in the case of the orange and the banana.

The associated citrus-fruit growers have accomplished the truly marvelous feat of selling during the past two seasons crops of fruit about 50 per cent larger than they had ever had before without causing a break in the market. And this has been done so effectively

that leading citrus men are now in a position to devote their attention to problems of production—for instance, malnutrition and frost protection—feeling that there is small cause for future anxiety as to a satisfactory market. It appears that the reason for this great marketing success has been in the effectiveness of distribution. New markets have been opened to some extent, but chiefly the supply has been so well distributed that there has been at all times and in all places merely a steady supply to meet the normal and healthy demand, with very few gluts or periods of scarcity.

In the banana industry we have a slightly different condition, but none the less a case of conspicuous marketing success. This, though a very perishable fruit, is so effectively distributed that it may be purchased almost anywhere throughout the year. If apples could be distributed as effectively there would be but little cause for worry about an oversupply of that fruit in the near future.

## KNOWLEDGE OF CROP CONDITIONS.

In connection with the production of truck crops, which are generally of a perishable nature, we need to know more of the area planted and how the crop is prospering during the growing period in the more important regions devoted to its production. This is largely a matter of more elaborate statistical and crop-reporting work.

In order to provide for the quick and economical gathering of such information and also for the most effective utilization of it when reported, communities of producers should be organized, so that large numbers of individuals may be reached through a comparatively small number of agencies.

When there is likely to occur any general oversupply of a perishable product, facilities should be available for the utilization of the surplus, either by canning, evaporating, or otherwise preserving it. If such methods are not possible the crop should be kept in the fields, where it will at least not work the double injury of costing the producer for its harvesting, packing, and shipping as well as of depressing the entire market below the point where there is a profit to anyone concerned.

With this same class of crops there is need for information as to the cost of production in different localities and as to the cost of getting the product to the markets. It is clear that in the case of some of our crops we have specialized too much in certain localities and not enough in others.

In the case of such slowly perishable products as grain, forage, and cotton, the economic problems are larger and more varied but none the less acute. It is not to be expected that much could be done in the way of limiting or increasing the acreage devoted to such crops

or in the way of holding them off the market in times of price depression. We already have elaborate systems for steadying the market in the form of crop reports and market quotations, but there is still need for improvement in the way of enabling the producer to share in the benefits resulting from the improved trade conditions which are now available but are not generally used. This is particularly true in the case of the cotton crop.

## CERTIFICATION OF CROPS.

As matters stand at present the man who produces cotton must sell his crop before he can conveniently realize any money on it, except, of course, where he borrows money on it before it is produced, as is too often the case. This is not so generally true of the man who produces grain. It is possible for the grain farmer, if the market conditions are not satisfactory, to borrow money on his crop at a low rate of interest, meet his obligations incurred in its production, and wait calmly for the market to come up to a point where he can sell at a profit. This advantage of the grain man over the cotton man is due to the fact that it is possible to certificate grain in storage in such a way as to make it a safe and satisfactory collateral for loans. This is not yet true with regard to cotton, though it would seem quite possible to provide such a system for general use.

I have not yet touched upon the subject of market requirements and prejudices. Under our present industrial conditions the producer and the consumer are seldom in direct contact. The products of our staple crops must pass through many hands. One unfortunate result is that the needs and discriminations of the consumer fail of reflection back through these devious trade channels to the producer. This is particularly true with respect to such commodities as are not utilized on or near the farm. Unless the producer can be made to feel directly the practical effect of the consumer's discriminations he will be guided in his choice of varieties, as well as in handling and marketing, by what suits his own particular fancy or preconceived and often inaccurate ideas of what the market demands.

The acute need that has been felt for improved methods of grading and standardizing our staple crop products has been due chiefly to this fact. It is sought through such improvements to bring about conditions more favorable for impressing upon the producer in a direct and effective way what the consumer wants and is willing to pay for. With this information the farmer may then decide intelligently whether the premium paid for high quality is sufficient to offset the lessened yield or the larger cost of production which may be attendant factors.

## SCOPE OF INVESTIGATIONS.

For several years we have been making investigations looking to standardizing the grades of grain. More recently, similar work has been taken up with respect to cotton. Much of the present efficiency with which the California citrus crop is picked, packed, and shipped is due to the brilliant work of one of the officers of this Bureau in that field. The same organization has extended its work into other branches of the fruit industry and is finding ways to inaugurate marked improvements.

Within the past year it has been found possible to begin a campaign in connection with the handling and marketing of cotton. It might be well to make a brief statement concerning this enterprise, since it represents an effort to focus industrially several phases of the Bureau's operations. For about 15 years we have been breeding and distributing improved varieties of cotton in the South. Had these new varieties of cotton been effectively utilized by southern farmers the present cotton crop would be worth intrinsically at least 25 per cent more than it is, representing a matter of at least $150,000,000. But these varieties have not been put into general cultivation. Two or three of them have found places in restricted localities and have displaced the older varieties, but none has yet made a discernible impression on the cotton industry. There have been two causes for this: (1) No adequate measures have been taken to preserve these new varieties by continued selection after they were distributed, and (2) the growers who received the seed in small lots had no means of getting the cotton through to the manufacturer in such a way as to receive the increased price that it was worth. These two difficulties must be overcome before we can make much progress in improving the quality and increasing the value of the cotton crop.

In 1904, when it became apparent that the boll weevil had come to stay and that it would probably spread throughout the cotton belt. the Bureau of Plant Industry was authorized to begin an educational campaign in the South to show how best to meet the ravages of this pestiferous insect. This movement has since become known as the Farmers' Cooperative Demonstration Work. A highly efficient organization has been developed, through which it is possible to reach a large proportion of the farmers of the South and to give them advice and encouragement.

Later, in 1909, the Bureau was authorized to investigate certain technological features of the cotton industry and to establish a set of official grades of cotton.

## COMMUNITY COOPERATION.

The latest step which has now been taken looks to a synthesis of these three lines of attack—a sort of coordination of the several kinds of work we are already doing, with a view to making each of them more effective. It is proposed to encourage communities of cotton growers to cooperate to the extent of planting some one improved variety of cotton, of keeping this variety pure and up to standard by continued selection of seed fields, and of marketing the cotton as nearly direct as may be, in order that the growers themselves may receive the higher prices which the cotton is worth and which the manufacturers have to pay. This is, of course, but the briefest statement of the plan. It involves the use of the new varieties which our breeders produce, the education of farmers in the roguing of these varieties in the field, the development of improved methods of ginning and of grading at the gin, and the direct sale of the crop by associations of growers, with the establishment of warehousing facilities to avoid market gluts and many similar improvements. All this requires a thorough understanding of the economics of the cotton business. Many different and important agencies must in the end be brought into harmonious working relations if this project is to be successful. There seems reason to hope that it can be done. Not easily, perhaps, but as the result of patient and persistent teamwork.

In a large measure, similar work is possible in other fields. We need to stimulate community action among producers to the fullest extent. It is almost hopeless for us to expect to reach the individual farmer. He is too many for us, but we can hope to reach many of the groups of associated farmers, even in the larger industries.

## CONCLUSION.

It may be that this subject has been treated more from the standpoint of sociology than of economics. But, after all, the two are not so far apart. The Bureau of Plant Industry represents one of the institutions established by society in the effort to provide itself with the necessities of life. We need occasionally to consider the larger phases of our problem—to take new bearings—for it is required of us not only that we execute the orders we receive, but also that we indicate what new orders should be given us.

I do not mean to intimate that we have solved all the problems of production. They come on endlessly, like the troubles from Pandora's box. But I do feel that the time has come for us to look at our agricultural industries as industries and to so shape our work that it

more nearly balances industrially. The temptation is strong for us to become merely a collection of specialists, each intent upon forwarding his own particular line; but we can not go on indefinitely in this direction. With every step of progress the field broadens. We are the servants of a patient and optimistic people. We have been given a broad charter and ample means, and we should do our utmost to justify the confidence that has been placed in us. This we can do most effectively by so welding together our specialties that when we combine to improve an existing industry or to establish a new one we may do really effective work.

Even in the work we are now doing we have acute need for the kind of information that is to be gained from investigations in the economics of crop disposal. Such investigations might spare us expensive efforts in the solution of production problems. In the case of many of our minor crops the important question often is not how best to grow them in a certain place, but whether or not it is worth while to grow them there at all. Such investigations are particularly appropriate to the Bureau of Plant Industry, since they involve interstate operations, while many of the production problems upon which we are engaged are more essentially local in their nature.

The particular plea that I wish to make is that as a group of men working together upon allied subjects we ought to give a larger proportion of our thought to the economic phases of the industries upon which we are at work.

# THE ABORTION OF FRUITING BRANCHES IN COTTON.[1]

By O. F. Cook, *Bionomist in Charge of Crop Acclimatization and Adaptation Investigations.*

## INTRODUCTION.

When cotton "grows too much weed" the farmer begins to fear for his crop. Strong, healthy growth of the young plants is desirable, of course, but excess of vegetative vigor is a real danger. Dry or infertile soils produce light crops because the plants remain too small, but luxuriant growth is also a limiting factor of production. Up to a certain point growth and fertility stand in a direct relation to each other, but beyond this point the relation is reversed. The larger the plants grow the smaller the crop is likely to be.

Abortion or restricted development of fruiting branches may be considered as the general cause of this inverse relation of growth to fertility in cotton, but there are several contributing factors that need to be taken into account. Even without actual abortion the growth of the fruiting branches may be greatly restricted by unfavorable conditions, so that little or no crop is produced. The most complete contrast between growth and fertility is shown when vigorous, rapidly growing young plants lose their early fruiting branches by abortion.

## CROWDING OF PLANTS IN THE FIELD.

Many farmers accept the general fact that overgrown plants are not very productive without feeling the need of a more detailed explanation; yet a moment's consideration would show that other factors must be involved in addition to luxuriant growth. Unless the large plants are different in other respects as well as in size, their more rapid development should result in earlier and larger crops instead of in later and smaller crops. With a better understanding of the habits of the cotton plant it becomes possible to see why the yield of cotton usually declines with increased luxuriance.

When a reason is given it is usually to the effect that the crop is reduced because large, luxuriant plants crowd each other in the field. But to understand this explanation we have to go still farther back. The true reason why crowding is so injurious is that the fruit

[1] Issued Mar. 22, 1913.

of the cotton plant is not borne on the main stalks and upright vegetative branches, but on specialized fruiting branches that grow out horizontally from the upright framework of the plant. When there are too many of the upright shoots normal development of fruiting branches becomes impossible because horizontal branches can no longer secure adequate exposure to the light. The main stalks and vegetative branches, having access to the light, are able to continue their upward growth, but this keeps all the lower parts of the plant under a canopy of shade.

New fruiting branches continue to be formed on the stalks and vegetative branches as they grow upward, and buds and flowers may be produced in great abundance, but before the fruit has time to develop, the fruiting branches that bear them are buried under so much shade that most of the bolls fail to attain a normal development. Many of the young bolls are blasted and fall off, while those that remain are usually undersized and open prematurely. The fiber of these premature bolls is also shorter and weaker than that of the well-developed bolls of the same plant, so that the first picking is often inferior to the second. But severe crowding may render the whole crop inferior in quality as well as small in quantity.

## FRUITING BRANCHES REPLACED BY VEGETATIVE BRANCHES.

According to prevailing theories of cotton culture, the dangers of crowding are to be avoided by having the plants farther apart, but even with ample spacing very large cotton plants may still produce very small crops, and in extreme cases none at all. In addition to the injuries which can be ascribed properly to crowding, luxuriant plants have other disadvantages that are not removed, but are even increased by wider spacing.

Large plants differ from small ones not only in size but also in having a much greater development of the vegetative branches, each of which behaves like an additional main stalk. As the vegetative branches develop from the lower joints of the main stalk and as each joint of the stalk, except in very rare cases, bears only one vegetative branch, the number of such branches can not be increased beyond a certain point without occupying the joints that would otherwise produce fruiting branches. Thus, in very luxuriant plants the vegetative branches are not only larger and more numerous but they occupy a larger number of joints at the base of the stalk.

In extreme conditions of luxuriance all of the fruiting branches may be replaced by vegetative branches, though the usual effect is that the fruiting branches begin to appear somewhat higher up on the stalk than on plants of more normal development. Though varieties differ somewhat in this respect it may be considered that the

normal position of the first fruiting branch is at about the sixth joint above the cotyledons in the Upland type of cotton and at about the eighth joint in the Egyptian type. Vegetative branches also develop very often from the axils of the cotyledons, making seven places for vegetative branches in Upland cotton and nine in the Egyptian, though it is not usual to find all of the joints producing branches.

The natural effect of deferring production of fruiting branches would be to postpone the formation of buds, flowers, and bolls, but other factors contribute to the same end and increase the disabilities of overgrown plants. Even when the vegetative branches can not be said to replace the fruiting branches in the sense of taking their places on the stalk, their development is often greatly in excess of what is desirable for purposes of crop production. Indeed, it would be an agricultural advantage if vegetative branches could be entirely suppressed. Cultural methods of avoiding the development of vegetative branches have been described in another paper.[1]

## COMPETITION OF VEGETATIVE BRANCHES WITH FRUITING BRANCHES.

Crowding plants in the field and replacing a few of the early fruiting branches with vegetative branches are not the only disadvantages of luxuriant growth. A much more serious factor is the crowding and competition between the two kinds of branches, for this continues throughout the season. Wider spacing does not avoid this more serious disadvantage of excessive vegetative development, for the reason that the inside of every large plant represents the same condition of shading and repression of fruiting branches as in a crowded field.

Even when large plants are allowed to stand well apart, so that the branches of different plants do not come in contact, each plant is able to establish a harmful shade of its own. When many vegetative branches are produced they surround the main stalk like a hedge and prevent the development of any normal fruiting branches within 2 or 3 feet of the ground. Although the fruiting branches may have begun a normal growth early in the season and reached the stage of flowering and fruiting, the subsequent thickening of the shade above them often prevents the maturing of any fruit, in the same way as when the plants are crowded in the field. Many of the buds or young bolls drop off, or some make a partial development, produce a little inferior fiber, and open prematurely. The branches that bear such bolls are small, slender, and short lived in comparison with those farther up on the stalk; many of them are dead and shriveled before the harvest season arrives.

[1] Cook, O. F. A new system of cotton culture. U. S. Department of Agriculture, Bureau of Plant Industry, Circular 115, 1913.

The method of very wide spacing is also objectionable for the reason that it induces the development of large numbers of vegetative branches and thus tends to defeat its own object of keeping the plants from crowding each other. With plants 6 feet or more apart, the competition between the two kinds of branches is somewhat lessened by the fact that the vegetative branches grow out at wider angles from the main stalk and do not interfere with the development of the lower fruiting branches. Enormous yields may be secured from individual plants in this way, but the heavily laden vegetative branches lie flat on the ground and the plan is quite impracticable for general crop purposes.

Notwithstanding the loss of all of its early fruiting branches a large, luxuriant cotton plant may still produce an abundant crop if given sufficient time. Though normal fruiting branches can not develop on the inside of such a plant because of the surrounding hedge of vegetative branches, there may be a heavy outside crop borne on fruiting branches that develop from the vegetative branches. Indeed, the main stalk of the plant is often outgrown by the vegetative branches when these are more accessible to the light.

In addition to the longer seasons required to produce crops on large, luxuriant plants, the labor of picking becomes more difficult and expensive, and a part of the crop may be lost by the lodging or breaking down of the vegetative branches. When the plants are so large that the crop must be borne on the outside, the weight falls on the exposed sides of the vegetative branches and bends them farther out until they finally give way. With large vegetative branches falling across the rows and becoming entangled with each other the fields become veritable thickets. The movements of the pickers are impeded and their efficiency reduced. This has been the difficulty in connection with Egyptian cotton in southern California and Arizona, because the Egyptian cotton grows larger and has a stronger tendency to produce vegetative branches, but Upland cotton often suffers in the same way, not only in the Imperial Valley of California but in Texas and elsewhere. Indeed, the luxuriance of the plants often has a more adverse effect upon the crop with Upland cotton than with the Egyptian, because the Upland cotton has denser foliage and is more susceptible to the shedding of the buds and young bolls.

## ABORTION OF FRUITING BRANCHES IN ADVANCE OF SHADING.

Though the considerations already noted have seemed sufficient to explain the inverse relation of growth to fertility, another fact indicates a still more fundamental conflict between the vegetative and reproductive functions. The failure of the fruiting branches to develop normally on the lower part of the stalk of a luxuriant plant

should not be ascribed to overshading alone. There is another form of abortion of the fruiting branches that begins to show itself even before the vegetative branches are large enough to keep the fruiting branches from receiving their full share of sunlight.

This physiological abortion of fruiting branches was observed at Bard, Cal., in May, 1912, in Egyptian cotton that had made normal growth during a rather cool spring, but which was beginning to show the effects of higher temperatures. As long as the weather continued cool the vegetative branches remained small and the plants were beginning to put forth fruiting branches when the warm weather began. The effects of the heat were soon apparent in an accelerated development of the vegetative branches, but the prosperity was not shared by the young fruiting branches, then from 2 to 4 inches long, which turned yellow and shriveled.

It had been expected that the fruiting branches would cease to develop as soon as the surrounding hedge of vegetative branches grew up around them, for this had been indicated by the results of previous experiments, but in this instance the abortion of the lower fruiting branches took place before the vegetative branches had grown tall enough to cast any shade upon the fruiting branches. Thus, it becomes apparent that there is a spontaneous physiological abortion of the young fruiting branches.

In addition to the injuries that arise from the fact that the development of vegetative branches results in unfavorable conditions for the fruiting branches it is necessary to recognize another unfavorable factor that acts directly through the plant, apart from the dwarfing of fruiting branches that are surrounded and overshaded by the vegetative branches. The conditions that favor luxuriant development of the vegetative branches are in some way directly inimical to the growth of the young fruiting branches, as though the latter were actually cut off or poisoned.

One suggestion is that the plants have two distinct phases or methods of performing their physiological functions, as well as two distinct kinds of branches. In the young plants the vegetative functions can evidently go on at temperatures that are unfavorable to a continuation of the reproductive functions, but temperatures can hardly be the only factor, for the fruiting branches of older plants are not aborted by hot weather.

The changes that often occur in the color of the foliage at the beginning of the flowering season may be connected with the passage from a vegetative to a reproductive phase. The two physiological color phases, though often apparent in Upland cotton, are particularly striking in the Egyptian. The foliage of young Egyptian plants in a condition of vigorous growth has a very deep bluish or

grayish green color and usually shows a definite change to a lighter and more yellowish green when the stage of budding and flowering is reached. Plants that grow under unfavorable conditions and are less vigorous show the yellowish tinge at earlier stages of development. This phenomenon was observed in Egypt in the season of 1910, as noted in a previous publication.[1]

Another possibility is that the abortion of the young fruiting branches, as well as the shedding of buds and young bolls, may be due to mechanical causes instead of being a direct result of chemical changes in the plant. To stop the growth of the buds or young bolls may be sufficient to produce abortion at a time when the vegetative framework of the plant is rapidly increasing in size. The buds appear to be "thrown off," as farmers often say, for extensive shedding often takes place within a day or two after a warm rain.

## CONCLUSIONS.

There is an inverse ratio of growth to fertility in cotton. Vegetative development often passes beyond the optimum, and then the crop becomes smaller as the plants become more luxuriant. The general reason for this is the competition of the vegetative branches with the fruiting branches.

The explanation usually given for the lessened yields of large plants is that it is due to the crowding of the plants in the field, but this is only one of several factors that interfere with a normal development of the fruiting branches.

The adverse effects of crowding are not avoided altogether by wider spacing of the plants in the field. The same unfavorable conditions that are brought about by the crowding of the plants in the field are found on the inside of every large plant. The fruiting branches are unable to attain a normal development. The early crop of buds and young bolls is often shed and the lower fruiting branches are often killed as a result of excessive development of the vegetative branches.

In addition to the losses that can be ascribed to crowding and overshading, a direct physiological abortion of the lower fruiting branches has been observed. This affords further evidence of the fact that conditions favorable to luxuriant vegetative development are unfavorable to crop production and shows the importance of cultural methods of avoiding luxuriant growth and suppressing the vegetative branches.

[1] Cook, O. F. Hindi cotton in Egypt. U. S. Department of Agriculture, Bureau of Plant Industry, Bulletin 210, 1911.

# FRUIT GROWING ON THE TRUCKEE-CARSON PROJECT.[1]

By F. B. Headley, *Farm Superintendent*, and Vincent Fulkerson, *Scientific Assistant, Office of Western Irrigation Agriculture.*

## INTRODUCTION.

No commercial orchards have been planted on the Truckee-Carson Project. Most of the first settlers along the Carson River made small plantings, chiefly of apples and pears, with a few trees of plums, apricots, and peaches. These orchards were small, seldom exceeding an acre in area, and were intended merely to supply the families with fruit.

The new settlers who have come in since the opening of the Truckee-Carson Project have planted small orchards, the largest of them containing only 3 or 4 acres. As these orchards are young and have only just begun to bear, our present knowledge of the fruit-growing conditions of the project rests chiefly on a study of the older orchards.

During the last four years the horticultural assistant at the experiment farm has been taking notes on these old orchards. Some of these have been surveyed and mapped and the varieties identified as far as possible. Notes have been taken on the behavior of the varieties, dates of blooming, and effects of frosts, diseases, insect pests, and of the high water table.

In the four years of observation there have been two full crops of apples and pears, one partial crop, and one failure. The failures that occur are due chiefly to late spring frosts.

## LOCATION OF ORCHARDS.[2]

Temperature observations have been made for several years to record the minimum temperatures on high lands and on adjacent low

[1] Issued Mar. 22, 1913.

[2] For more complete information in regard to methods of fruit growing, see—

Waite, M. B. Commercial pear culture. U. S. Department of Agriculture, Yearbook for 1900, pp. 369–396.

Gould, H. P. Fruit growing for home use in the central and southern Great Plains. U. S. Department of Agriculture, Bureau of Plant Industry, Circular 51, 1910.

Brackett, G. B. The apple and how to grow it. U. S. Department of Agriculture, Farmers' Bulletin 113, 1909.

——— The pear and how to grow it. U. S. Department of Agriculture, Farmers' Bulletin 482, 1912.

lands, and these records show that the night temperature on the higher lands is, on the average, several degrees warmer than on the low lands. On still nights the cold air settles to the lower levels. Because of this fact it is better to plant all fruit trees that are subject to injury by frost on the higher elevations. A north slope is preferable to a south slope, as the former does not warm up so much on the warm days of spring, and in consequence the trees are somewhat retarded in coming into bloom. The danger of frost injury is therefore lessened. An important point to consider in locating the orchard is the situation with regard to underground water. Several of the small orchards on the project have been killed by the rise of the water table. If the trees are planted on comparatively high ground this danger is lessened or avoided.

## AGE AND SIZE OF TREES FOR PLANTING.

It is usual to plant fruit trees that are 1 or 2 years old. One-year-old trees have the advantage over older trees in that they are usually cheaper and their form can be shaped as the grower desires. When the trees are to be purchased by a grower who does not understand pruning, it is conceivable that better results may be obtained by purchasing older trees on which the heads have already been formed. The man who understands pruning, however, often prefers the 1-year-old trees, so that he may form the heads to suit his own ideas. It is not advisable to plant trees older than 2 years, as such trees are likely to be culls left over from former years. The older trees are less likely to start into vigorous growth after being transplanted, because of the severe pruning necessary on both roots and tops.

## DISTANCE APART TO PLANT TREES.

Many of the old orchards of the project were planted with trees too close together, which resulted in crowded and misshapen trees. Crowded trees can not spread out and the bearing wood is forced to the tops, resulting in a decreased yield and putting the fruit where it is not easily gathered. Figure 1 gives a view of an apple orchard near Fallon where the trees were only 1 rod apart.

Safe distances for planting fruit trees in Nevada are 32 to 36 feet apart each way for apples and 16 to 20 feet apart for pears, peaches, plums, prunes, cherries, and apricots.

In the case of apple orchards, quick-bearing varieties may be planted in the center of each square, these trees, or "fillers," as they are called, to be cut out as soon as the trees of the orchard begin to crowd. Good varieties to use for fillers are Oldenburg (*Duchess of Oldenburg*), Wagener, Missouri, and Wealthy. These varieties will

come into bearing four to six years after planting and need not be cut out until they are about 12 years old.

## CARE OF TREES WHEN RECEIVED.

When the bundle or box of trees from the nursery is received, it is a good plan to unpack and heel them in at once in moist soil in a location close to the proposed orchard. When ready to plant, they may be taken out as wanted and put into the ground without much exposure of the roots to the sun and air. If the roots of the trees are

FIG. 1.—An apple orchard near Fallon, Nev., in which the trees are only 16 feet apart. Such close planting prevents the proper spreading of the branches, forces the bearing wood to the tops of the trees, decreases the yield, and makes spraying and picking difficult.

dipped in a puddle of thin mud as soon as they are taken from the heeling-in bed, the chances of failure will be still further reduced. Before putting into the ground, all broken and damaged roots should be pruned back with a clean cut.

## LAYING OUT THE ORCHARD.

Before digging the holes for the trees the entire orchard should be laid out and a stake placed in the ground at the proposed location for each tree. The stakes can be put into perfectly straight lines,

which will help materially in getting the trees into perfect alignment. Detailed instructions for laying out the orchard can be obtained from some of the bulletins and circulars listed in the footnote on page 17.

## PLANTING.

Previous to planting any of the trees the holes may be dug and the stakes replaced in the center of the holes, care being taken to see

FIG. 2.—A 1-year-old whip, uncut, on the right, and cut back to 18 inches, on the left. Three or four branches are allowed to grow.

that the lines are kept straight. The holes should be large, so that the trees may be placed in them without bending the roots, and the trees should be set 3 to 4 inches deeper than they were in the nursery where grown. In case the subsoil is hard it is well to loosen it up a few inches deeper than the roots are set. The soil thrown in should be firmly packed about the roots of the trees with the feet several times during the filling of the hole. If irrigation can not be given immediately after the trees are set, a bucket of water should be emptied into each hole before it is entirely filled, unless the soil is already sufficiently moist.

Since the prevailing winds are from the west or southwest, the trees should be planted with the tops inclined slightly toward the southwest. If this is not done, the winds are likely to bend them to the east.

The symmetry of the trees can also be favorably influenced when pruning by leaving the terminal buds on the branches to the windward side; in other words, the trees should be more closely pruned on the side away from the prevailing winds than on the opposite side.

## PRUNING.

As soon as the trees are planted they should be pruned back, so that the tops will not be too large for the roots to support. If the

FIG. 3.—A 2-year-old tree, uncut on the left, and properly pruned on the right. Such branches are left as will produce a strong, symmetrical head.

tree is a 1-year-old whip, it should be cut back to about 18 inches above the ground (fig. 2). Branches will start below this point and only three or four of them should be allowed to grow.

When 2-year-old trees having a number of branches are set out, the main leader should be cut off and the branches pruned so as to leave three or four branches on different sides of the tree, in order to form a well-shaped, symmetrical head, as shown in figure 3. These branches should not be allowed to branch off from the same point, as shown in figure 4, since the crotch is liable to split when the tree is grown and becomes loaded with fruit.

If a low branching system is not formed while the trees are young it is usually difficult to prune them so as to get a well-shaped head in later years. Figure 5 illustrates a pear tree which has been allowed

to grow in a natural form. The result is a tree having a shape very undesirable on account of the difficulty with which the tree can be sprayed or the fruit gathered. Most of the bearing wood is at the top of such a tree.

A more desirable form of top for an apple tree is shown in figure 6. This form of tree has two faults: One is that the branches come

FIG. 4.—A 2-year-old tree improperly pruned. When the main branches start from the same point on the trunk, the tree is almost certain to be broken when it is loaded with fruit. Compare with figure 3.

out from too nearly the same point, resulting in a crotch that is likely to split some time when the tree is well loaded with fruit, and the other is that the top is rather too dense.

## CARE OF THE ORCHARD AFTER PLANTING.

After the trees are planted, the orchard may be given clean cultivation, or some form of cultivated crop may be grown between the rows until the trees come into bearing, when clean cultivation should

be the rule. Suitable crops to grow between the rows of trees are small fruits or garden vegetables.

To keep the ground well fertilized and the trees growing rapidly, barnyard manure may be applied around the trees during the winter and disked under in early spring, or winter vetch may be seeded late in September, to be plowed under the following May. The vetch

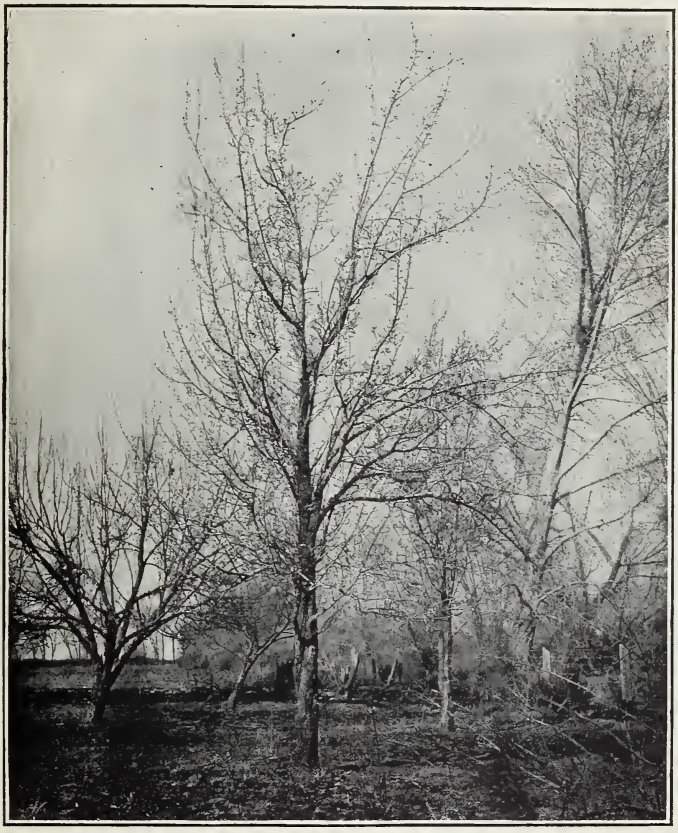

FIG. 5.—An unpruned pear tree. When the trees are not properly trained the tops are liable to be too high, making spraying and fruit picking very difficult.

adds a large quantity of organic matter to the soil, which is needed by most of the desert soils of the project.

## IRRIGATION.[1]

Orchards are usually irrigated by furrows running parallel to the tree rows. Sufficient water should be given to keep the trees grow-

[1] For more complete information, see U. S. Department of Agriculture, Farmers' Bulletin 404, entitled "Irrigation of orchards," 1910.

ing well, but in case there is a high water table, water on lands in and near the orchard should be cautiously used, for if the water table should rise above the lower part of the root system for any length of time the trees would probably be killed. Trees in some of the old orchards have been killed in this manner, the water table under the orchards having risen after the adjacent higher lands had been put under cultivation. Figure 7 shows trees in an orchard 5 miles

FIG. 6.—An apple tree having a good top, with respect to height and general outline. It is faulty in that the main branches come out too nearly at the same point and the top is somewhat too dense.

from Fallon that have been killed in this manner. The trees in the background were on higher land and were not noticeably affected.

## ORCHARD HEATING.

Experiments were made in the spring of 1911 and again in 1912 to test the efficacy of orchard heaters in protecting the orchards from frost. Several of the well-known makes of heaters burning crude oil were used. The tests were not of practical use in saving the crop, but it was demonstrated that the temperature in the orchards can be held at 4 or 5 degrees above the temperature outside the orchards on comparatively still nights. All the tests made were on areas less than half an acre in size. On such small areas the real efficiency of the

heaters could not be determined, as their efficiency is increased with the area heated. In small blocks a large proportion of the heat is lost which would have been used in heating other trees in the case of large orchards. A difference in temperature of 4 degrees might frequently be sufficient to save the fruit crop.

## VARIETIES.

Farmers as a rule have not had much experience in fruit growing and are therefore usually at a loss to know what varieties to plant in

FIG. 7.—Apple trees killed by the rise of the water table in an old orchard near Fallon, Nev.

their home orchards. Nearly every nurseryman has certain new varieties or novelties that he is exploiting, and these or others of uncertain value are the ones tree agents too often succeed in persuading the farmers to buy. Generally these novelties are not as good as the old standard varieties, and if the farmer wants to be safe he will select at least all but a few of his trees from the standards.

Below is given a list of the standard varieties of fruit trees most commonly grown in Nevada or in the mountain plateau regions of Utah, California, Washington, and Oregon. These varieties are known to do well in Nevada or in near-by States having similar climatic conditions and are suggested for planting in Nevada.

APPLES.

Summer varieties:
- Yellow Transparent.
- Red Astrachan.
- Oldenburg (*Duchess of Oldenburg*).
- Maiden Blush.
- Gravenstein.
- Benoni.

Fall and early winter varieties:
- Wealthy.
- Fall Pippin.
- Jonathan.
- Wagener.
- Grimes (*Grimes Golden*).

Winter varieties:
- Baldwin.
- Rhode Island Greening.
- Yellow Bellflower.
- Rome Beauty.
- White Pearmain.
- Winesap.
- Gano.
- Ralls (*Ralls Genet*).
- Ben Davis.
- Banana.

A commercial orchard should contain not more than two or three varieties at the most, but there is no great objection to planting a large number of varieties in the home orchard.

APRICOTS.

Apricots seem to be less reliable in this region than peaches and should not be planted extensively. If it is decided to plant some apricots, selection should be made from the late-blooming varieties. Standard varieties are Moorpark, Royal, Blenheim, Hemskirke, and Peach.

CHERRIES.

Sweet cherries have usually been unsatisfactory in the intermountain climate and therefore should not be planted extensively on the Truckee-Carson Project until a greater knowledge has been obtained as to their reliability. The common sour and Duke varieties are the most promising. Some of these varieties are Richmond, Morello, Montmorency (*Montmorency Ordinaire*), and May Duke.

Some growers will desire to try some of the sweet varieties, even though they are not so likely to succeed as the ones mentioned. In such a case the following are suggested as desirable varieties for trial: Tartarian (*Black Tartarian*), Napoleon (*Royal Ann*), Bing, Wood, Lambert, and Elton.

PEARS.

The Bartlett is a great favorite and is of excellent quality, but is more subject to blight than some of the other varieties. The Kieffer is a desirable variety and is somewhat more resistant to blight than the Bartlett, but the quality is not so good. Varieties suggested are Bartlett, Clairgeau, Clapp Favorite, Flemish (*Flemish Beauty*), Kieffer, Seckel, and Winter Nelis.

### PEACHES.

Peaches are not reliable bearers on this project and can not be recommended for planting extensively. Most farmers, however, in planning their home orchards will desire to include a few peach trees so that they may be able to enjoy the fruit during favorable seasons. Varieties suggested for trial are:

Early variety—Alexander.
Midseason varieties—Foster, Early Crawford, Elberta, Late Crawford, Muir.
Late varieties—Salway, Phillips (*Phillips' Cling*).

### PLUMS.

Varieties suggested for trial are Columbia, Burbank, Bradshaw, Peach, and Yellow Egg.

### PRUNES.

Agen, Italian, German, Golden Drop, and Pond are suggested.

## DISEASES.

The most serious disease affecting fruit trees on the Truckee-Carson Project is the blight of apples and pears.[1] This disease is at present not widely spread and if those having orchards will take pains to keep it out of their own plantations it is not likely to become serious.

Sun scald is caused by the hard freezing and sudden thawing of the bark on the southwest side of the trunk during the winter and early spring. Preventive measures are to whitewash the trunk or to shade it in some manner. Common methods are to lean the tree several degrees toward the southwest when planting or to shade the trunk with boards or cornstalks.

Alkali land or land having a high water table should be avoided when the orchard is planted. After the orchard is growing it might be found somewhat difficult to wash out the alkali without injuring or killing the trees.

## INSECTS.[2]

The insect causing the greatest amount of damage to the apple crop is the codling moth. Damage to the fruit by this insect is greatly lessened by spraying when the petals have fallen with a solu-

[1] See article in U. S. Department of Agriculture, Yearbook for 1895, by M. B. Waite, entitled "The cause and prevention of pear blight."

[2] For more complete information in regard to insects on fruit trees, see the following publications, all issued by the U. S. Department of Agriculture, Bureau of Entomology: Circulars Nos. 54, The peach-tree borer; 32, The larger apple-tree borer; 81, The aphides affecting the apple; 20, The woolly aphis of the apple; and Bulletins Nos. 97, pt. 2, Life history of the codling moth and its control on pear in California; and 115, pt. 2, The one-spray method in the control of the codling moth and the plum curculio.

tion of lead arsenate in the proportion of 2 pounds of the arsenate paste to 50 gallons of water. Those who decide to spray for this insect should first secure reliable directions for carrying on the work.

Borers have been found in some young trees, but they have not been doing much general damage. The borers usually enter at some injured point on the bark of the tree. It is therefore advisable to take every precaution to keep the bark in a healthy uninjured condition. Whitewashing to prevent sun scald helps to keep out the borers by keeping the bark healthy. When borers get under the bark of trees they should be dug out and destroyed. If the borers succeed in girdling the trunk they will cause the death of the tree. For this reason it is wise to watch the young trees carefully, so that the borers will not have an opportunity to do serious damage before they are removed. Their presence is usually indicated by the accumulation of castings at the mouth of the burrow.

Woolly aphides have been found in some orchards, but do not seem to be doing serious damage.

# THE EXCRETION OF CYTASE BY PENICILLIUM PINOPHILUM.[1]

By KARL F. KELLERMAN, *Physiologist in Charge of Soil-Bacteriology and Plant-Nutrition Investigations.*

## INTRODUCTION.

For many years it has been apparent that the continual destruction of large quantities of cellulose in nature was insufficiently explained by the action of the processes of rapid combustion alone. The biological activities of several species of bacteria and molds are usually considered a satisfactory explanation of the destruction of the greater portion of the cellulose annually deposited upon the soil,[2] yet the existence of true cellulose-dissolving enzyms or cytases even now is questioned.[3]

## TECHNIQUE OF ISOLATING CELLULOSE.

A rather simple method has been developed that seems adequate for demonstrating that cytases produced by aerobic fungi may exist even when separated from the living organism which produced them. Swedish filter paper is dissolved in Schweitzer's reagent, precipitated in dilute hydrochloric acid, and washed by decantation in several changes of dilute hydrochloric acid and later in pure water until no evidence of either copper or chlorin can be detected by acid potassium ferrocyanid or silver nitrate. Appropriate quantities of this amorphous mass of pure cellulose are thoroughly mixed with nutrient agar media,[4] tubed, and sterilized in an autoclave for 20 minutes at 20 pounds pressure. When the agar has cooled almost to the congealing point it is well to shake the tubes gently

[1] Issued Mar. 22, 1913.

[2] Kellerman, Karl F., and McBeth, I. G. The fermentation of cellulose. Centralblatt für Bakteriologie, Abt. 2, Bd. 34, no. 18/22, p. 485–494, 2 pl., 1912.

McBeth, I. G., and Scales, F. M. The destruction of cellulose by bacteria and filamentous fungi. U. S. Department of Agriculture, Bureau of Plant Industry, Bulletin 266, 50 p., 4 pl., 1913.

[3] Euler, Hans. General Chemistry of the Enzyms. Tr. from the rev. German ed. by Thomas H. Pope. New York, 1912, p. 13.

[4] The medium most frequently used is composed of cellulose, 5 grams; agar, 10 grams; potassium phosphate, dibasic, 0.5 gram; magnesium sulphate, 0.5 gram; sodium chlorid, 0.5 gram; ammonium sulphate, 1 gram; calcium carbonate, 1 gram; tap water, 1,000 cubic centimeters.

in order to insure an even distribution of the flocculent cellulose. Tubes of this character, inoculated upon the surface with the spores or mycelium of some cellulose-dissolving fungus and kept from 20 to 40 days in a moist atmosphere at a temperature of 30° C., show a cleared zone in the upper layers. The hyphæ of the fungus usually penetrate the medium for only a few millimeters of the culture medium, as shown in figure 1.

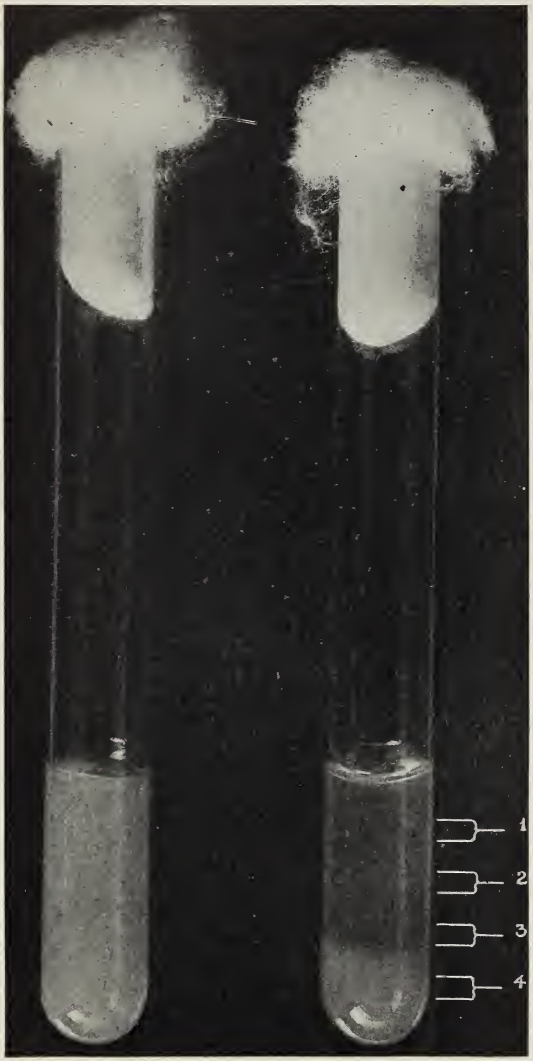


FIG. 1.—Culture tubes showing the action of *Penicillium pinophilum* when growing upon media containing amorphous cellulose. At the left a sterile tube of cellulose medium is shown for comparison.

A tube in this condition may be scratched with a file or diamond glass cutter near the bottom at the point where it must later be broken; the lower half of the tube is dipped in a disinfecting solution, such as 0.2 per cent mercuric chlorid, and wiped dry with sterile filter paper. The bottom of the tube is cracked entirely around and removed by means of sterile forceps; the cotton plug in the mouth of the tube is pushed down the tube against the culture, and the entire plug of agar is forced sufficiently beyond the broken rim so that by means of a sterile knife several sterile sections may be cut and transferred immediately to the surface of a previously cooled layer of cellulose agar in a Petri dish. The cytase will diffuse slowly from

the sections into the substratum, and at a temperature of 30° C. the clarifying action is usually noticeable within 72 hours.

## DEMONSTRATION OF ACTION OF CYTASE.

Figure 2 shows the relative effect of agar charged with cytase taken at different depths from the growing fungous layer. From a culture of *Penicillium pinophilum* Hedg.,[1] 28 days old, four sections, each approximately one-eighth of an inch in thickness, were cut from the relative positions indicated by the brackets numbered 1, 2, 3, and 4 in figure 1. It should be noted that section No. 4 is entirely below the

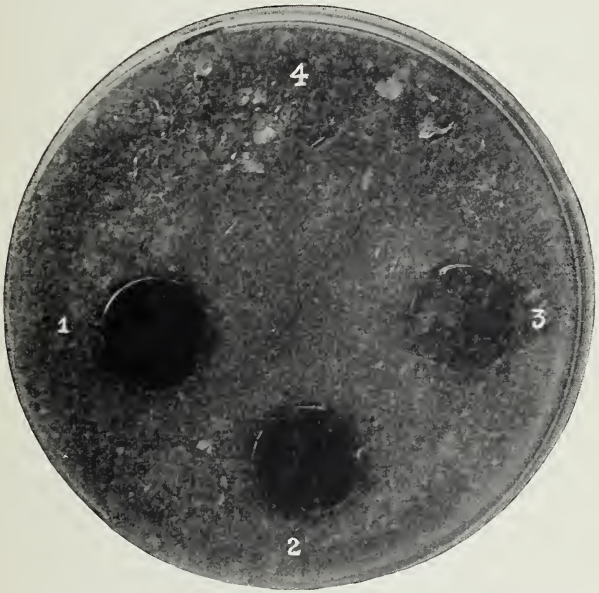


FIG. 2.—Result of the action upon amorphous cellulose of sections of agar which contain a cytase produced by *Penicillium pinophilum*.

cleared zone and contains flocculent callulose apparently identical with that in the sterile tube. These four sections were transferred to a firm layer of cellulose agar in a Petri dish and held at 30° C. for five days. They were then removed, carefully examined, and found to be sterile; yet, as shown in figure 2, the amorphous cellulose held in suspension immediately beneath section No. 1 was more or less completely dissolved. It was dissolved to a less degree under section No. 2, but slightly under section No. 3, and was unaffected under section No. 4.

It is obvious from this demonstration that true cytases, slowly diffusible through agar, may be isolated in appreciable quantities.

[1] Identified by Dr. Charles A. Thom, Mycologist in Charge of Cheese Investigations, Bureau of Animal Industry, U. S. Department of Agriculture.